Great Lakes Environmental Research Laboratory
Laboratory Science Review
March 22-24, 2016

GLERL's Response to Science Panel Review Recommendations

9 May 2017

Submitted by:
Deborah Lee, Great Lakes Environmental Research Laboratory Director

Introduction

Laboratory science reviews are conducted every five years to evaluate the quality, relevance, and performance of research conducted in the National Oceanic and Atmospheric Administration (NOAA) Office of Oceanic and Atmospheric Research (OAR) laboratories. The NOAA Great Lakes Environmental Research Laboratory (GLERL) Program Review occurred March 22-24, 2016 in Ann Arbor, MI. GLERL appreciates the time and effort devoted by the Review Panel to thoroughly evaluate and review its science and technologies. We found the recommendations to be insightful, positive, and informative for guiding GLERL's future.

This review covered GLERL research since 2010. The research themes presented included Observing Systems and Advanced Technology (OSAT), Ecosystem Dynamics (EcoDyn), and Integrated Physical and Ecological Modeling and Forecasting (IPEMF). The review agenda, presentations, posters, and guiding materials are available on the GLERL website: https://www.glerl.noaa.gov/review2016/.

In this report, each actionable recommendation provided by the Science Review Panel is italicized and followed by GLERL's response. A table summarizing the actions with timelines for completion is included at the end of our report.

GLERL Recommendation Response

General Recommendations

GR 1: Steps should be taken to improve the cross-pollination and interoperability of the Branches.

In response to this observation, the GLERL Director is initiating a new lab-wide meeting structure, which includes a number of cross-branch working groups at the leadership, supervisor/branch and team level, to improve both vertical and horizontal communications. The lab has re-instituted quarterly "All-PI" meetings to provide a venue specifically for cross-pollination and coordination. The meetings focus on free-ranging discussion of science topics of interest to the PIs including current and emerging science, collaboration processes, and potential joint proposals. Additionally, GLERL's Leadership Council, which includes all science and infrastructure branch chiefs, reviews all draft proposals. This enables the Council members to identify collaboration opportunities while proposals are in development.

GLERL's Information Services (IS) team (in conjunction with our Cooperative Institute) coordinates the Great Lakes Seminar Series with invited speakers to give formal presentations. These presentations are followed by robust Q&A sessions and small group/individual meetings among scientists. The IS team also coordinates an informal brown bag series; scientists across branches discuss topics of their choosing. GLERL has also instituted an internal newsletter that includes science highlights, upcoming travel, staff updates, and field work updates to increase awareness of laboratory activities. GLERL continues to offer a number of informal "open to all" gatherings regularly throughout the year to foster unstructured opportunities during core working hours for staff to mingle and get to know one another (e.g. monthly teas, occasional potlucks and picnics.)

GR 1 Action Plan: In 2017, GLERL will conduct Quarterly All-PI meetings focused on developing collaborative projects for high priority research topics, and proposals are being reviewed by GLERL's Science Council for collaboration opportunities. The GLERL Director is introducing new collaborative cross-branch teams (Data Management, Communications & Web team).

GR 2: There should be a concerted effort to more transparently document models and provide data to the public. The panel heard several examples of historic datasets that are not readily available to scientists outside of GLERL or the general public.

In response to the need for data accessibility, GLERL incorporated a framework for a Data Management Plan (DMP) into the new Implementation Plan, issued as a companion document to GLERL's Strategic Plan. The framework (pp. 40-42) details the objectives and milestones

needed to comply with federal policy to increase Public Access to Research Results (PARR) and NOAA's Environmental Data Management Policy (NAO 212-15). To begin the process of compiling and integrating the component parts of GLERL's DMP, GLERL leadership has convened a data management planning committee to develop a concept plan. The concept plan addresses technical, organizational, and resource aspects of data management at GLERL. The plan includes a five-year schedule of milestones (FY17 - FY21). A significant challenge to fulfilling the new data management directives is staffing. Three full-time positions are recommended: 1) Data Manager/Spatial Analyst, 2) Web Developer/Programmer and 3) Data Analyst. These positions are listed as priority hires in the 2016 GLERL Staffing Plan.

GR 2 Action Plan:

- **In 2017, GLERL will finalize the GLERL 2017-2021 Concept Plan for Data Management.**
- **The GLERL Staffing Plan includes hiring a Data Manager/Spatial Analyst and Web Developer/Programmer. Hiring packages have been developed.**
- **GLERL is continuing to catalog historical data sets.**
- **GLERL will conduct training sessions for PIs and data collectors on data formatting and metadata requirements.**

GR 3: It is very important for the Lab to continue the geophysical monitoring programs. Only a government agency can hope to get the commitment and funding to keep up monitoring programs for long periods of time. For example, monitoring the invasive species counts is necessary to figure out how the population changes both temporally and spatially. Monitoring is an important activity that should be appreciated and continued.

GLERL shares in this commitment to continue long-term biophysical monitoring programs as shown in the GLERL 2016-2020 Implementation Plan in the EcoDyn Branch Paths and Milestones (pp. 6-7). The following paths are directly relevant. Additional paths and annual milestones are listed in the plan.

- Continue to monitor the status of benthic macroinvertebrate and dreissenid mussel populations in Lake Michigan and conduct experiments to evaluate factors that affect mussel abundance, feeding, growth, and condition in the Great Lakes as well as mussel impacts on Great Lakes food webs.

- Continue to define and understand spatial interactions of nutrients and food-web components from microbes to fishes in lakes Michigan and Huron, and their consequences to food web production using state of the art technologies e.g., fisheries acoustics, laser optical plankton counter, and environmental sensors.

GLERL's unique datasets are the foundation of its science program across all three science branches and GLERL communicates the relevance of these data sets through its Information Services Branch using innovative multimedia and infographics. GLERL's challenge is to balance the resources required to conduct this monitoring with the resources to conduct new and

emerging science. We continually look for efficiency and cost-savings in all that we do to meet this challenge and we actively seek out funding opportunities to supplement our base budget.

GR 3 Action Plan: GLERL's commitment to continuing biophysical monitoring is evident in the 2016-2021 Implementation Plan: EcoDyn Theme Paths (pp. 6-7), where GLERL has identified annual milestones in out years specific to the continuation of long-term monitoring programs.

GR 4: While it is perfectly understandable and expected that GLERL would focus on the Great Lakes, there was a consensus [1] by all reviewers that expanding publications and scientific interactions with societies outside of the Region could be of benefit to both GLERL as well as audiences outside of the Great Lakes.

GLERL looks to form collaborations and exchanges with other scientists of the world to expand beyond the Great Lakes where there is benefit to be gained. GLERL has ongoing collaborations or is working with scientists on HABs in a variety of locations: in rivers or reservoirs (Florida; Korea), estuaries (Chesapeake Bay), coastal areas (New York, Florida), and lakes (Lake Taihu in China; Lake Winnipeg, Manitoba). GLERL has been involved for a number of years with hypoxia in the Gulf of Mexico. GLERL also has a very active Arctic program with interactions with Russia, China and other nations. GLERL is also encouraging its scientists to seek publication and presentations in forums with broader scientific communities. GLERL will stagger PI attendance at regional meetings to once every 2 to 3 years, and use those resources to attend conferences of national and international societies.

GR 4 Action Plan: GLERL PIs will stagger conference attendance between Great Lakes and national meetings. GLERL PIs are actively applying for funding opportunities for projects outside the Great Lakes.

GR 5: a) Due to the large amount of personnel and skills support that is obtained from CILER, the Division would be extraordinarily impacted if not available; b) A large amount of funding for CILER comes through the Great Lakes Restoration initiative (GLRI), which can be reduced or terminated at any time; c) Because of the close interaction with institutes within the agreement there is a potential vulnerability of CILER representing itself as a government spokesperson or entity; and d) potential appearance of personal services. It was difficult at times to understand where the lines between GLERL and CILER existed. While there were certainly no observations of improprieties, it is a vulnerability that, if not actively managed, could endanger the agreement. It may be

[1] Since review panels are not authorized by the Federal Advisory Committee Act, they cannot reach a consensus. Therefore, it is understood that the intent of the word "consensus" here was to convey that all of reviewers came to the same conclusion, individually.

useful to seek an internal NOAA audit of the agreement and practices to determine what (if any) steps may be necessary to mitigate any potential risks.

GLERL is well aware of the vulnerabilities posed by loss of a cooperative institute and dependence on Great Lakes Restoration Initiative funding. We are happy to report that NOAA's Executive Council has approved the re-compete of a cooperative institute, and we look forward to the outcome. While loss of future Great Lakes Restoration Initiative funding would be detrimental to GLERL's programs, GLERL ensures that it can operate in a fiscally sound manner on its base funding alone. GLERL is increasing its engagement across NOAA's line organizations and within OAR's programs to seek funding in addition to its base. GLERL has had recent success, receiving competitive CHRP (Coastal Hypoxia Research Program), and is awaiting confirmation of (Research Transition Acceleration Program (RTAP), and National Water Initiative funding for FY17 and FY18. GLERL also works closely with its partners such as the International Joint Commission, US Army Corps of Engineers, and others through which it receives external funds.

With respect to potential vulnerability of the Cooperative Institute for Limnology and Ecosystems Research (CILER) representing itself as a government spokesperson or entity due to GLERL's close interaction, and the potential appearance of personal services, the Cooperative Agreement clearly spells out roles and responsibilities of the NOAA grantors and the CILER grantees. While we have not observed any personal services, management will remain vigilant for such interactions. GLERL management prohibits receipt of any services from CILER outside the scope of the grant, does not accept any personal services from CILER. GLERL and CILER management have instituted quarterly meetings to discuss such issues. In addition, GLERL and CILER communications leads provide their staff with templates for posters and presentations. Prior to dissemination, draft products are reviewed by communications staff for appropriate messaging, funding, and partner acknowledgements. Practice sessions for presentations at major science meetings are convened and presentations are critiqued.

GR 5 Action Plan: GLERL continually seeks and obtains additional funding through a variety of non-GLRI sources—in 2017 GLERL is identifying funding opportunities within NOAA, pursuing significantly more NOAA funding than ever before (NOAA Oceanic and Atmospheric Research (OAR)/Climate Program Office; NOAA/OAR/Office of Weather and Air Quality (OWAQ), NOAA/National Ocean Service (NOS)/National Centers for Coastal Ocean Science (NCCOS).

<u>Ecosystem Dynamics Theme</u>

ED 1) There *is a need to maintain current and evolving comprehensive hiring strategies for backfilling retiring staff. There was no staffing plan or hiring strategy provided to the panel for review although mentions of such a plan existing was made on a couple of occasions. As retirements occur, the senior leadership of GLERL should take those*

opportunities to back fill those positions (when possible) with a balance of federal principle investigators AND support staff. Senior leadership should be leery of relying too heavily upon cooperative agreements such as that with CILER for senior science leadership and support.

In 2015, GLERL senior leadership developed and periodically updated a comprehensive staffing plan that provides a mechanism for identifying requirements for new positions, prioritizing the needs of the Divisions, and strategically planning for new federal hires. Due to problems with lack of Federal base funding and issues with NOAA's Workforce Management, GLERL has hired only a few new EcoDyn Federal employees in the last five years to replace departed staff. EcoDyn was particularly hard hit by staff departures since the last laboratory review. EcoDyn hires in the last three years have included a phytoplankton/HABs ecologist with molecular skills (Davis) and a benthic ecologist (Elgin). In addition, we replaced a contract biological technician with a federal technician in support of EcoDyn's LTR program at our Lake Michigan field station in Muskegon.

Davis is covering part of the gap caused by the retirement of a senior phytoplankton (primary production) ecologist (Fahnenstiel) and the departure of a junior molecular HABs ecologist (Dyble), both of whom left GLERL approximately 5 years ago. Elgin is covering the position vacated by our senior benthic ecologist (Nalepa) and another benthic ecologist both of whom retired roughly 6 years ago.

EcoDyn/GLERL formally initiated the hiring process of a biophysical modeler; however, we put the process on hold due to budget uncertainties. As seen from the presentations, the biophysical modeler is important to our goal of projecting results of our observations, experiments and concepts to scenario models and forecasts.

EcoDyn management also recognized the need to hire a phytoplankton production/microbial food web ecologist to fill a critical gap lost to our food web team and Great Lakes science. We are pleased the review team concurs with the need for this position. This proposed hire replaces and enhances the primary production ecologist position lost to retirement. As shown in some of our presentations and recent publications, there has been a resurgence of interest in the microbial food web (MFW). Likewise, there has been a rapid development in methodology for primary production in oligotrophic systems. We were the leaders in this area, and this gap is a major loss to Great Lakes science and critical mass to our food web team. In the short term, it may be possible to use base funds and external funding to support help in this critical area.

EcoDyn not only recognizes the need to backfill retired support staff, but also to enhance capabilities by hiring support staff familiar with emerging tools. This is a critical time for the branch in that a new wave of retirements is ongoing or expected. It will enhance the program to replace the retirees with support staff who have recently acquired skill sets that match newly developed methods and techniques, and who have quantitative skills not typically found in biological technicians of earlier generations. At this time, our ability to hire new support staff is limited given the current fiscal climate, which negatively affects the program.

EcoDyn is aware of the danger of relying too heavily on the Cooperative Institute for Limnology and Ecosystems Research (CILER) staff to fill senior and support positions. At the same time, we recognize the important role they fill. Advantages of CILER positions have been their ability to seek science and infrastructure funds for which federal staff cannot compete as well as their having expertise we cannot afford to pay for. Disadvantages include differing research priorities of university scientists and staff supported by soft money. Hiring federal staff in key areas will make sure GLERL priorities remain front and center. For example, a federally funded biophysical modeler hire can focus entirely on critical GLERL research priorities. Likewise, the primary production/microbial position will help restore an EcoDyn/GLERL vision to its science.

ED1 Action Plan: Per the GLERL staffing plan, we plan to fill the biophysical modeler position and a phytoplankton/microbial specialist; we will backfill appropriate support staff as they retire.

ED 2) The [Ecosystems Dynamics] Branch should improve public accessibility to data and models. Key data sets from long term monitoring programs are not easily obtainable for the public or outside scientists. While the panel cannot provide a list of those data sets not easily obtainable, questions posed to several presenters and other scientists indicated that while staff at GLERL are happy to share information and make data available upon request, the data are not readily available for general scientific or public utilization.

Like other NOAA/Oceanic and Atmospheric Research (OAR) laboratories, GLERL is under NOAA Administrative Order (NAO) 212-15: Management of Environmental Data and Information. GLERL science management has developed a data management plan for FY 2017-2021 that, by its sweeping nature, addresses the reviewers' concerns on data availability. Full adoption of this mandate depends on finding sufficient funds to cover additional positions to carry out the plan. The data management plan, as it pertains to EcoDyn activities, is similar in many respects to that developed for the NSF LTER sites.

GLERL recognizes that some of its biological data are not readily available to the public. The following are examples of GLERL's available data, data sharing practices, and current activities working to make additional data available.

Data from the GLERL/CILER lower Great Lakes monitoring program are posted on the GLERL HABs and Hypoxia Water Quality and Monitoring data page (https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/habsMon.html) including:

- Western Lake Erie HAB data since 2008.
- Water quality data (2013 – 2016), from multiple sites throughout western Lake Erie. Saginaw Bay, Lake Huron (bi-weekly) and Lake St. Clair (in collaboration with the University of Windsor and Environment and Climate Change Canada).

- Near real-time water quality data from the GLERL/CILER western Lake Erie continuous monitoring network is also posted to the GLERL HABs and Hypoxia webpage (see link above) throughout the bloom season (May – October).

Many of the most critical water quality data, including chlorophyll a, phycocyanin, microcystins and other physiochemical parameters are analyzed within 48 hours of collection and a western Lake Erie weekly data share is sent to several regional stakeholders (including drinking water managers at the Toledo, OH and Monroe, MI water treatment plants) and academic partners.

EcoDyn observations and experiments are also made available via interpreted products (typically journal articles) describing, explaining, or modeling system changes. We have been moving to make the underlying data available—if not already presented in user-friendly form in figures or tables—at time of publication. For example, the Rowe et al. (2015) article (presented at the program review) on a geospatial mapping of mussel biomass and impact on the spring phytoplankton bloom, published the original mussel biomass survey data and spatial data sets of biomass distribution produced by the geostatistical model as an online supplement to the journal article. As an additional example, code for the Lagrangian particle dispersion model that was modified in development of the HAB Tracker forecast model, was made available by returning it to the Finite Volume Community Ocean Model code repository (Rowe et al., 2016—also presented at the program review).

These data are also displayed for public consumption at the GLERL HABs and Hypoxia Water Quality and Monitoring data page (https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/habsMon.html). Furthermore, near real-time water quality data from the GLERL/CILER western Lake Erie continuous monitoring network is also posted to the GLERL HABs and Hypoxia webpage (see link above) throughout the bloom season (May – October).

Additionally, GLERL is currently going back through our (legacy) data that were collected before 2009 as part of our long-term observations and experiments in Lake Michigan. Although we have published many of these data in peer-reviewed literature, we intend to organize the data in a way that others can easily access them for internal and external use through publications, supplements to published journal articles, or data sets themselves.

ED 2 Action Plan: Actions to improve accessibility are included in the lab-wide Data Management Plan (see also *General Recommendation 2*). Specific actions relevant to EcoDyn in 2017 are: (1) compile long-term data sets from the Muskegon transect studies conducted during 1983-2015 and (2) update dreissenid density and biomass maps for the southern basin and the whole Lake Michigan.

ED 3a) The ED research program should seek to broaden its scientific publishing audience and scientific community involvement outside of the Great Lakes area. While the work done by scientists within the ED research program is well known and respected within the Great Lakes community, seeking a broader scientific audience would increase the

visibility of the group and division nationally and internationally as well as potentially provide insight to research questions that may be needed in the future for the Region.

We recognize that we need to increase our visibility beyond the Great Lakes region in terms of impact through service on international boards, development of international collaborations, and publishing in high impact international journals. We value this actionable advice to increase our profile and will do so.

It is worth noting, however, that our high impact papers have resulted from studies done on the Great Lakes. In all of these cases there were scientific advances based on site-specific or regional studies. Studies outside of the region are also beginning to be important. One of EcoDyn's most highly cited papers on HABs arises out of work carried out at a variety of locations. Our HABs program includes research on estuaries, coastal regions, rivers, and lakes in many parts of the US, Canada (Laurentian Great Lakes and Lake Winnipeg), and China. It is not surprising our HABs ecologist sits on a number of national and international boards and works with leading scientists in these countries. Another area of international collaboration has been in the area of invasive species. There has been a long history here nationally and internationally with dreissenid mussels. At present, our most important international interactions outside of Canada are with China, from where Asian carps originated. Likewise, we are actively collaborating with US scientists on Asian carp problems outside of the Great Lakes region.

ED 3b) There are several topics I expected to hear at the project-level that were noteworthy by their absence or limited mention. These are: (a) ecosystem-based management, (b) ecosystem-based fisheries management, (c) ecosystem services (a little), (d) coupled human-natural systems, (e) integration and synthesis (not just how the projects fit together within Lab and NOAA but how the science methods and results come together), (f) database development, (g) high performance computing resources, (h) zooplankton dynamics, (i) uncertainty and risk analysis, and (j) overarching but detailed conceptual models of how key components of the ecosystem interact to which projects methods and results can be mapped.

Regarding the many topics we did not cover explicitly by using the aforementioned phrases or concepts (a-d) but instead emphasized the NOAA research themes to demonstrate alignment with NOAA, if we understand correctly, the reviewers would have been interested in more nuts-and-bolts material on how we carry out the projects and how they fit together. In response: we do have a coherent process though we did not emphasize this in our presentations. Below are a few brief comments on the listed items e-j:

- (e) Integration and synthesis: For our LTR work, results and synthesis come together by observing an important (representative) site over a long period and measuring important processes to understanding, which leads to scenario models and forecasts that are useful to adaptive management of the Great Lakes. We will elaborate on this in our response to the next recommendation (ED.4) posed to the group.

- (f) Database development: This is an area where we are working to improve.
- (g) High performance computing resources: Although not specifically mentioned, the sophisticated modeling work of Rowe required high-performance computation (HPC) necessary for putting the ecological model in an FVCOM hydrodynamic framework requiring computations at small spatial scales. Rowe has attended important workshops on this subject. EcoDyn shares HPC resources with IPEMF, which are administered by professional IT staff.
- (h) Zooplankton dynamics: We have one of the most extensive data sets on seasonal dynamics of zooplankton collected on the Great Lakes. In addition to the time series work at Muskegon, we are doing work on spatial structure of zooplankton in the context of how the total food web (microbes to fishes) organizes itself at fine scale spatially and temporally, which is necessary for understanding larval recruitment, nutrient regulation strategies, and climate impacts. The presentation on spatial work focused mostly on fishery issues and downplayed cutting-edge work on zooplankton and how the whole system fits together.
- (i) Uncertainty and risk analysis: This is always a concern. The Asian carp model adopted novel measures of uncertainty (structured expert judgement), and risk analysis was presented as part of the presentation on new invaders in the system.
- (j) Overarching but detailed conceptual models of how key components of the ecosystem interact to which projects method and results can be mapped: This was a shortcoming of our presentation format. We chose to present "exciting" projects and had all PIs and some collaborators participate to present material, whether or not it resulted in a coherent whole. We will pick this up in the next major recommendation to the group.

ED 3 Action Plan: To address concerns of broadening our research audience and community involvement, we will target more of our publications for international journals and, where appropriate, seek NOAA cross-line office connections as well as international collaborations of mutual benefit. (*see also General Recommendation 4*)

ED 4) The ED Research program should seek to improve the unit's scientific connections and cohesion among projects within the group. As new projects are developed, principle investigators and branch chiefs could present proposals to the branch and seek opportunities for cross-pollination.

To move forward to address this recommendation we will briefly summarize some of the LTR program connectivity and suggest ways to move forward.

The LTR program at present is composed of the following major mutually reinforcing subprojects:

1. Monthly observations Lake Michigan (Pothoven)—has a pelagic (nutrients, lower food web and fish connections) long-term focus.
2. Benthic surveys and tracking dreissenid population dynamics (Elgin)—benthic long-term focus.
3. Spatial studies and Microbes (Vanderploeg)—examines almost all components of the food web (microbes to fishes) simultaneously along with appropriate physical and chemical variables (using advanced technologies) to specify how the system organizes itself at fine temporal and spatial resolution. Most EcoDyn PIs are involved in this team project as well as two university colleagues working on the microbial food web.
4. Mussel feeding and nutrient (Vanderploeg)—examines the two main drivers by which dreissenid mussels affect ecosystems. We combine measurements of these processes with information in Subproject 2 to explain observations in Subprojects 1 and 3 and to develop scenario models of ecosystem impact of dreissenids under varying conditions of nutrient loading and climate.

In recent years, these mutually reinforcing projects have resulted in a number of highly cited important contributions to understanding Great Lakes ecological function with implications to other systems. Results from all subprojects and earlier work of Fahnenstiel on primary production led to a series of important papers on the system-wide impacts of dreissenids, the first of which dealt with the decimation of the spring phytoplankton bloom and a new concept on how the system spatially organized itself after the dreissenid invasion. Modeling work presented by Rowe integrated observations and experimental results from all subprojects (1-4) with a hydrodynamic model from the IPEMF group in order to evaluate ecosystem-scale effects of invasive species, and scenarios of changing nutrients and climate. Moreover, none of the observations made by EcoDyn would have been possible without heavy support in field observations from OSAT. As another example, we have published on factors driving seasonal zooplankton abundance and composition building on the long-term data set. However, we can tighten the interactions among projects to increase connectivity and impact. For example, we can better coordinate the experiments on mussel feeding and nutrient excretion with the experiments on mussel abundance and condition to achieve a larger impact. Continued interaction between biophysical modeling and experimental ecology benefits both fields; empirical work helps the models to become more realistic, and models allow the results of biological monitoring and process studies to be extrapolated to ecosystem-scale effects and for consideration of scenarios that inform management decisions.

Except for small base-funded efforts on *Microcystis* buoyancy and dreissenid impacts to HABs in Lake Winnipeg, the inter-branch, interdisciplinary program on cyanoHABs is externally funded. As noted in the program, the project is co-led by an EcoDyn PI (Tim Davis) and an IPEMF PI (Eric Anderson). This highly successful and productive program depends on collaborative effort from all branches, the NOAA National Ocean Service (NOS), CILER, and academics. This interdisciplinary program incorporates cutting-edge research, monitoring, and advanced technologies (e.g. Environmental Sample Processor) to further elucidate the factors driving HABs and predict their abundance, spatial distribution and toxicity. The data collected are used by GLERL/CILER researchers to develop and improve regionally important predictive

products including the Lake Erie Experimental HAB Tracker and the Lake Erie Experimental HAB Bulletin. This program is an exemplar of a cross-branch, cross-line office and regional stakeholder collaboration. Furthermore, the GLERL/CILER HAB team meets regularly to review progress and make plans. However, we are always looking for ways to make improvements in connectivity, balance, and vision.

Both the Asian carp and GLANSIS projects are externally funded. The Asian carp studies are beginning to rely heavily on LTR work and other EcoDyn observations as it seeks to develop the next generation of spatially explicit forecasts of habitat suitability that will use an end-to-end ecosystem model (the Atlantis Ecosystem Model) to integrate inputs from OSAT, EcoDyn and IPEMF. The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) project is being upgraded with new attention from several EcoDyn PIs and an infusion of Great Lakes Restoration Initiative (GLRI) money.

ED 4 Action Plan: To increase connections and cohesions, we will better coordinate observations, experiments, and modeling in the LTR and HABs programs to produce products that increase fundamental understanding and forecasts important to NOAA and our diverse stakeholders.

*ED 5) The panelists noted that this program had a particular skill mix conducive to high quality work in modeling lower food chain dynamics. However, modeling of higher trophic position species was also apparent and may even be duplicative with other federal resource management agencies (e.g. USGS). While it is certainly the prerogative of branch and division to invest resources into future research efforts, the panelists would urge the research program to consider some of their core strengths in prioritizing future research efforts and partner with other federal agencies to complement those strengths***.**

This issue has historical roots that date back to the period of 1997 to 2007 when there was a wave of retirements or resignations in a number of disciplines (chemistry, geochemistry, physical limnology, snow and ice, two benthic ecologists, ecological modeling) and their replacement at the time by many fisheries postdocs and PIs. The infusion of fisheries science at GLERL has had the advantage of connecting the lower food web to fisheries, which is important to stakeholders (fisheries managers, state natural resource agencies and tribes) and NOAA's mission. GLERL expertise in making these connections as demonstrated in many interdisciplinary studies, publications, and presence on influential working groups, has been important to understand the effects of multiple stressors on fisheries production particularly factors responsible for fish recruitment. A major strength of GLERL's program has been connecting fish to the lower food web based on a combination of observations, experiments and food web and ecosystem models. We have developed and been involved in developing food web models for four of five Great Lakes, and we are the first and the only one, to our knowledge, developing and applying a comprehensive ecosystem model for the Great Lakes. Much of our research is complementary to research at other federal agencies (e.g., U.S. Geological Survey fish monitoring program and population dynamics studies). We have worked very well with other agencies and academics in

complementing, rather than competing, with each other's work, as for example in the multi-agency Coordinated Science and Monitoring Initiative studies and the Saginaw Bay multi-stressors study, which was very important to Michigan Department of Natural Resources. However, at the same time we recognize we have compromised our capacity to provide mechanistic understanding of bottom-up food web dynamics on fisheries and water quality with loss of expertise in many areas, particularly in the primary production and microbial food web areas and nutrient biogeochemistry. We need a new focus provided by new hires or collaborations to rebalance our program.

ED 5 Action Plan: We will definitely consider our core strengths in prioritizing future research efforts and partner with other federal agencies to compliment those strengths and specifically will follow through with the following actions. We plan to rebalance our staffing to improve the understanding of the lower trophic levels and biogeochemistry, which has been our historical core strength and at present is a weak link in understanding of Great Lakes food webs. In the near term, hiring a phytoplankton/microbial ecologist will be a big help here (see above). We will continue to work with EPA, USGS, the Great Lakes Fishery Commission, state agencies, tribes, and the International Joint Commission to make sure our programs complement rather than duplicate other efforts.

Observation Systems and Advanced Technology

OSAT 1) Performance within OSAT could improve by incentivizing non-research engineers to publish in appropriate journals of their expertise and for scientists that are publishing to diversify their journal contributions and target audiences beyond the Journal of Great Lakes Research (JGLR). Overall, panelists were impressed with the technology developed and utilized at GLERL, but their work is not generally benefitting science audiences unfamiliar with JGLR. Similarly, OSAT engineers are encouraged to increase efforts to reach out to organizations in Canada of similar research interests in the Great Lakes to exchange innovative technologies and maximize coverage of monitoring in the region.

GLERL will provide training for publishing engineering R&D results in journals with wider distribution, such as the IEEE Journal of Oceanic Engineering and the Marine Technology Society Journal. GLERL engineers have agreed to a timeline for publishing technology development successes, beginning in 2018 and yearly thereafter. GLERL is also working with the NOAA OAR Technology Partnership Office to gain a better understanding of the Tech Transfer process. GLERL will also discuss a plan with a timeline for publishing technology development successes.

In addition to current research collaborations with Canadian scientists on airborne hyperspectral observations, GLERL will also return to biennial research collaborations on observing technology with scientists and engineers at the Canada Centre for Inland Waters in Burlington, ON. OSAT researchers and engineers will continue collaborations with scientists and engineers

at the OAR/Atlantic Oceanographic and Meteorological Laboratory, the OAR/Pacific Marine Environmental Laboratory, the Monterey Bay Aquarium Research Institute, the Woods Hole Oceanographic Institute, the Harbor Branch Oceanographic Institute, and other similar institutions.

OSAT 1a Action Plan: GLERL will provide training for publishing engineering R&D results in journals with wider distribution, such as the IEEE Journal of Oceanic Engineering and the Marine Technology Society Journal. Also, GLERL engineers have agreed to a timeline for publishing technology development successes, beginning in 2018 and yearly thereafter.

OSAT 1b Action Plan: In addition to current research collaborations with Canadian scientists on airborne hyperspectral observations, GLERL will also return to biennial research collaborations on observing technology with scientists and engineers at the Canada Centre for Inland Waters in Burlington, ON. OSAT researchers and engineers will continue collaborations with scientists and engineers at AOML, PMEL, the Monterey Bay Aquarium Research Institute, the Woods Hole Oceanographic Institute, the Harbor Branch Oceanographic Institute, and other similar institutions.

OSAT 2) OSAT should ensure that buoy monitoring systems have core technology capable of reporting key parameters that are a standard fare outside of this research group. The specific example given by panelists was instrumentation capable of measuring and reporting short and long-wave radiation. However, as engineers reach out to external entities, other endpoints of import may be discovered and incorporated.

Long and short-wave radiation sensors were installed on one of GLERL's RECON buoys during the 2014 and 2015 field seasons through a partnership with the University of Michigan's Department of Civil and Environmental Engineering. This project served as a stepping-stone towards broader use of radiometers on Great Lakes structures and buoys with the goal of deploying surface moored observations using a suite of standard instrumentation (Weller et al 2012) used to monitor air-sea interactions.

OSAT 2 Action Plan:

- **GLERL will continue its expansion of the use of long and short-wave radiation sensors with the goal of broader use of radiometers on Great Lakes structures and buoys.**
- **Deploy a year-round, under-ice ReCON station in western Lake Erie, reporting waves, currents, temperature, ice characteristics, and HAB data profiles (Proposal submitted – pending funding).**
-

OSAT 3) Continue to ensure strong interactions between research scientists and engineers. If not already occurring, OSAT engineers should promote their innovative approaches within the other two branches such that new research questions may be developed through opportunities borne from their technological advances.

Observational capacity developed by OSAT engineers for research vessels and buoys is currently being used by EcoDyn, IPEMF and OSAT researchers on multiple projects such as ecosystem understanding, meteotsunamis, model validation, and lake evaporation. However, additional communications will be enhanced with annual emerging technology discussions and monthly all-hands meetings.

OSAT 3 Action Plan: In fall 2017, the OSAT Branch Lead will initiate a biennial retreat with PIs from all GLERL research branches, MIL, and Vessel Operations to discuss emerging observations technologies to identify new research questions.

Integrated Physical & Ecological Modeling & Forecasting Research Program

IPEMF 1) IPEMF should maintain and expand topical modeling expertise. Specifically, the very relevant and ongoing research and expertise in hydrodynamic modeling should be maintained while expanding the expertise in the group with ecological/ecosystem modeling. As a group charged with integrating the expertise of the division, the omission of ecological/ecosystem modeling expertise in the group is quite notable

IPEMF continues to maintain, improve, and transition hydrodynamic model and forecasting capabilities by developing state-of-the-art, high-resolution, 3-dimensional hydrodynamic modeling systems. In addition, IPEMF integrates and expands atmosphere-hydrodynamic-ice-hydrological-wave-sediment-ecology modeling components, following NOAA's unified modeling strategy and approach. The GLERL staffing plan has already identified the need for the cross-branch hire of a biophysical/ecological modeler and the position description and a recruiting package has been developed. A post-doctoral scientist has been hired to work on developing a coupled hydrodynamic-ecosystem modeling system. IPEMF works closely with ecological modelers in the EcoDyn branch where hydrodynamic models are linked with ecological and ecosystem models. IPEMF also leverages the expertise of the NOAA cooperative institute, CILER, on ecological modeling and academia's expertise on hydrodynamic modeling and data assimilation.

IPEMF 1 Action Plan: IPEMF will follow the NOAA unified and integrated modeling approach to develop and improve existing modeling expertise. Hydrodynamic modeling capability will be maintained and hydrological and ecological modeling capabilities will be expanded and enhanced. The GLERL staffing plan approves a new hire of a biophysical modeler.

IPEMF 2) Developing models to their "operational" stage is a clearly identified goal of the IPEMF Research group. While this may be the ultimate goal of many of the deliverables produced by the Branch, the level of effort and research conducted to get to that goal is high while the level of visibility and documentation of those efforts are relatively low. While the panelists recognized the challenges involved with increasing

the visibility of these efforts, they none-the-less encouraged researchers within the group to identify intermediate stages of model development to publish results of model testing and scenario building as a way to describe the "science of going operational".

There are at least two technical reports published by NOAA NOS for every Great Lakes Operational Forecast System that has been transitioned to operation: 1) a technical memorandum for model development and hindcast skill assessment, and 2) a technical report for semi-operational skill assessment. IPEMF recognized the need for more visibility, stakeholder engagement, and publication aspects. Several actions have been taken to address the review panel's suggestions: 1) present model development and operation status at annual Great Lakes conferences to increase user awareness and visibility, 2) host a user engagement and stakeholder workshop for every new forecast system, and 3) publish model development, testing results and operational status in Great Lakes related journals.

In addition, to fulfill NOAA's mission by transitioning research models into operations, new frontiers in research to improve modeling and forecasting capabilities, such as model coupling, data assimilation, and ensemble forecasting, have been identified as the top IPEMF research priority. One example: IPEMF scientists will chair a session on model integration and data assimilation at this year's International Association for Great Lakes Research conference to encourage community collaboration on this topic. Model development and test result have been published in prestigious journals such as the Journal of Climate, Journal of Geophysical Research, and widely circulated Eos.

IPEMF 2 Action Plan: 1) IPEMF will follow the NOAA unified and integrated modeling approach to identify top research priorities. 2) Model development and testing results will be documented in technical reports and publications. 3) Conferences, workshops, and user engagement meetings will be held to increase visibility and awareness.

IPEMF 3) All panelists had comments recommending improved coordination with the IPEMF branch with other Branches in the Division; especially given the name of the Branch and its identified mission. While this certainly was not a common theme across all research efforts (HABs forecasting being an obvious example to the contrary), reviewers believed more should be done to increase collaborations among the Branches such that the integrated modeling efforts would harvest appropriate information for modeling efforts. Similar to recommendations in other research groups, reviewers recommend developing mechanisms to increase the potential for interaction and sharing of information at the project planning and development stage of model development.

All three branches work closely on both internal and external research projects that require close collaboration and coordination on fieldwork design, instrument deployment, modeling and forecasting, and data verification. Cross-branch and division meetings to explore new research proposal and opportunities have been held on a regular basis, both formally (bi-weekly science

council, quarterly all-PI) and informally. The NOAA Oceanic and Atmospheric Research/Climate Program Office /Modeling, Analysis, Predictions, and Projections proposal referenced above was written by IPEMF, EcoDyn, and CILER scientists to apply existing climate, hydrodynamics and biophysical models to develop seasonal forecasts of food web dynamics and fish distributions in Lake Michigan. The National Science foundation (NSF) proposal on meteotsunamis involves IPEMF and OSAT as well as several academic institutions.

IPEMF 3 Action Plan: Establish all principal investigators meetings to encourage cross-branch, interdisciplinary discussions on a regular basis. Establish a new proposal routing procedure to promote cross-branch collaboration opportunities. ***(see also General Recommendation 1)***

IPEMF 4) The IPEMF research group should improve steps to document their model inventory and capabilities. The Branch should consider taking this time of transition in leadership and turnover of senior scientists to take stock in past and present integrated modeling efforts internally along with parallel efforts of groups doing similar work to determine if critical niches in Great Lakes modeling are not being addressed. In developing any potential new research themes and model development, the IPEMF group should consider steps necessary to document the rationale behind choosing existing models, or why there was a need to develop a new one when necessary.

With the new NOAA environmental data management directives and the next generation global prediction system (NGGPS), IPEMF is currently documenting the model inventory as well as data and model output that are available for users and Great Lakes stakeholders. Collaborative relationships with academia and other government agencies have been established to leverage different research topics. Rationales behind modeling system selection were determined at the NOAA level among all OAR and line offices. For example, FVCOM and ROMS have been selected as NOAA's operational coastal models by NOS.

IPEMF 4 Action Plan: IPEMF will create a complete inventory for all computer models, capabilities, data, and model outputs. Following NOAA environmental data management (EDM) and Public Access to Research Results (PARR) directives, GLERL has developed a comprehensive data management implementation plan and data will be disseminated to the public in accessible and user-friendly ways (see GR 2).

GLERL Science Review Action Sheet			
Section	**Recommendation**	**Action**	**Target Date**
General Recommendations *Champion: Science Council*			
General.1	Improve the cross-pollination and interoperability of the Branches. Break down any existing "stove pipes"	- In 2017, GLERL will conduct Quarterly All-PI meetings focused on developing collaborative projects for high priority research topics, and new proposals are being reviewed by GLERL's Science Council for collaboration opportunities. - The GLERL Director is introducing new collaborative cross-branch teams (Data Management, Communications & Web team).	4/2018
General.2	Make a concerted effort to more transparently document models and provide data to the public.	- In 2017, GLERL will finalize the GLERL 2017-2021 Concept Plan for Data Management. - The GLERL Staffing Plan includes hiring a Data Manager/Spatial Analyst. - GLERL is continuing to catalog historical data sets. - GLERL will conduct training sessions for PIs and data collectors on data formatting and metadata requirements.	4/2018
General.3	Continue the geophysical monitoring programs.	- GLERL's commitment to continuing biophysical monitoring is evident in the 2016-2021 Implementation Plan: EcoDyn Theme Paths listed on pp. 6-7, GLERL has identified annual milestones in out years specific to the continuation of long-term monitoring programs.	4/2018
General.4	Expand publications and scientific interactions with societies outside of the Region to benefit GLERL and audiences outside of the Great Lakes.	- GLERL PIs will stagger conference attendance between Great Lakes and national meetings. - GLERL PIs are actively applying for funding opportunities for projects outside the Great Lakes.	4/2018

General.5	Protect against the vulnerabilities of having a large amount of personnel and skills being supported through CILER and the large amount of funding for CILER comes through the Great Lakes Restoration initiative (GLRI) which can be reduced or terminated at any time	- GLERL continually seeks and obtains additional funding through a variety of non-GLRI sources—in 2017 GLERL is identifying funding opportunities within NOAA, pursuing significantly more NOAA funding than ever before (OAR/CPO; OAR/OWAQ, NOS/NCCOS)	4/2018
Ecosystem Dynamics Theme Action Items *Champion: Henry Vanderploeg*			
ED.1	Maintain current and evolving comprehensive hiring strategies for backfilling retiring staff.	- Per the GLERL staffing plan, we plan to fill a biophysical modeler position and a Phytoplankton/Microbial specialist; we will backfill appropriate support staff as they retire.	4/2018 & ongoing
ED.2	Improve public accessibility to Ecosystem Dynamics branch data and models.	- Improved access to EcoDyn data is included in the lab-wide Data Management Plan (*see also General2*); specific to EcoDyn in 2017: o Compile long-term data sets from the Muskegon transect studies conducted during 1983-2015. o Update dreissenid density and biomass maps for the southern basin and the whole Lake Michigan.	4/2018
ED.3	The ED research program should seek to broaden its scientific publishing audience and scientific community involvement outside of the Great Lakes area.	- We will target more of our publications for international journals and, where appropriate, seek NOAA cross-line office connections as well as international collaborations of mutual benefit. *(see also General4)*	4/2018 & ongoing
ED.4	The ED Research program should seek to improve the unit's scientific connections and cohesion among projects within the group.	- We will better coordinate observations, experiments, and modeling in the LTR and HABs programs to produce products that increase fundamental understanding and forecasts important to NOAA and our diverse stakeholders.	4/2018

ED.5	ED program should consider their core strengths in prioritizing future research efforts and partner with other federal agencies to complement those strengths.	- We plan to rebalance our staffing to improve the understanding of the lower trophic levels and biogeochemistry, which has been our historical core strength and at present is a weak link in understanding of Great Lakes food webs. - We will continue to work with EPA, USGS, the Great Lakes Fisheries Commission, state DNRs, Tribes, and International Joint Commission to make sure our programs complement rather than duplicate other efforts.	4/2018 & ongoing
OSAT Theme Action Items *Champion: Steve Ruberg*			
OSAT.1a	Improve OSAT performance by incentivizing non-research engineers to publish in appropriate journals of their expertise and for scientists that are publishing to diversify their journal contributions and target audiences beyond JGLR**.**	- GLERL will provide training for publishing engineering R&D results in journals with wider distribution, such as the IEEE Journal of Oceanic Engineering and the Marine Technology Society Journal. - GLERL engineers have agreed to a timeline for publishing technology development successes, beginning in 2018 and yearly thereafter.	4/2018
OSAT.1b	OSAT engineers are encouraged to increase efforts to reach out to organizations in Canada of similar research interests in the Great Lakes to exchange innovative technologies and maximize coverage of monitoring in the region.	- In addition to current research collaborations with Canadian scientists on airborne hyperspectral observations, GLERL will also return to biennial research collaborations on observing technology with scientists and engineers at the Canada Centre for Inland Waters in Burlington, ON. - OSAT researchers and engineers will continue collaborations with scientists and engineers at AOML, PMEL, the Monterey Bay Aquarium Research Institute, the Woods Hole Oceanographic Institute, the Harbor Branch Oceanographic Institute, and other similar institutions.	4/2018

OSAT.2	OSAT should ensure that buoy monitoring systems have core technology capable of reporting key parameters that are a standard fare outside of this research group.	- GLERL will continue its expansion of the use of long and short-wave radiation sensors with the goal of broader use of radiometers on Great Lakes structures and buoys. - Deploy a hypoxia-monitoring mooring in the Sandusky Basin. - Deploy a year-round, under-ice ReCON station in western Lake Erie, reporting waves, currents, temperature, ice characteristics, and HAB data profiles (Proposal submitted – pending funding).	4/2018
OSAT.3	Continue to ensure strong interactions between research scientists and engineers. OSAT engineers should promote their innovative approaches within the other two branches such that new research questions may be developed through opportunities borne from their technological advances.	- In fall 2017, the OSAT Branch Lead will initiate a biennial retreat with PIs from all GLERL research branches, MIL, and Vessel Operations to discuss emerging observations technologies to identify new research questions.	4/2018

IPEMF Theme Action Items *Champion: Philip Chu*			
IPEMF.1	IPEMF should maintain and expand topical modeling expertise. Specifically, the very relevant and ongoing research and expertise in hydrodynamic modeling should be maintained while expanding the expertise in the group with ecological/ecosystem modeling.	- IPEMF will follow the NOAA unified and integrated modeling approach to develop and improve existing modeling expertise. Hydrodynamic modeling capability will be maintained and hydrological and ecological modeling capabilities will be expanded and enhanced. The staffing plan approves a new hire of a biophysical modeler.	4/2018 & ongoing
IPEMF.2	Encourage researchers within the group to identify intermediate stages of model development to publish results of model testing and scenario building as a way to describe the "science of going operational".	- IPEMF will follow the NOAA unified and integrated modeling approach to identify top research priorities. - Model development and testing results will be documented in technical reports and publications. - Conferences, workshops, and user engagement meetings will be held to increase visibility and awareness.	4/2018 & ongoing
IPEMF.3	Increase collaborations among the Branches such that the integrated modeling efforts would harvest appropriate information for modeling efforts. Develop mechanisms to increase the potential for interaction and sharing of information at the project planning and development stage of model development.	- Program wise, cross-branch meetings and discussions have been established on regular basis. - All new proposals and projects will be routed through all branches to identify potential collaboration opportunities. *(see also General1)*	4/2018

IPEMF.4	The IPEMF research group should improve steps to document their model inventory and capabilities. The Branch should consider taking this time of transition in leadership and turnover of senior scientists to take stock in past and present integrated modeling efforts internally along with parallel efforts of groups doing similar work to determine if critical niches in Great Lakes modeling are not being addressed. In developing any potential new research themes and model development, the IPEMF group should consider steps necessary to document the rationale behind choosing existing models, or why there was a need to develop a new one when necessary.	- IPEMF plans to create a complete inventory for all models, capabilities, data, and model outputs. Following NOAA environmental data management and PARR directives, a data management plan has been developed and data will be disseminated to the public in accessible and user-friendly ways.	4/2018 & ongoing